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THE FLAME HARDENING PROCESS

By ROLAND H. LYNCH

THE Romans had a way of doing it. As legend goes, the Roman warriors hardened their swords by heating them to whiteness and then plunging them through the mid-section of their favorite slave. This *did* temper the sword but it was somewhat hard on the slave.

Today there are a variety of processes for hardening steels, the most universal being the relatively simple heating and quenching method. As it implies, the steel is merely held above its critical point for a definite length of time, then quickly cooled by immersion in oil or water. The principal limitation of this method lies in the fact that the steel is hardened to the same extent throughout and this is undesirable in many cases.

This limitation of the heating-quenching process naturally led to the development of other methods of hardening designed to produce a part having an extremely hard surface yet a tough ductile core. In case carburizing—a more or less well-known example of this type of hardening—the part to be hardened is surrounded by a carbonaceous material and held at a high temperature until the surface of the steel absorbs a certain specified amount of carbon. This is followed by reheating and quenching, the result being a hardened surface of different composition from the softer, ductile core. However, processes such as case carburizing require considerable time and are not readily adaptable to all types of parts.

The inadequacy of these methods led to years of experimentation and research which culminated in the recent development of a process, "flame hardening", combining the simplicity of the heating and quenching method with the ideal features of the case-hardening processes. In this method the surface to be hardened is quickly raised to the required temperature by means of the oxy-acetylene flame and instantly cooled by means of an oil or water stream although an air blast is occasionally sufficient.

The flame hardening process has a number of outstanding advantages over other hardening methods. The hardening of huge machine parts, practically impossible by the methods heretofore used, is now relatively simple. A variety of applications require a hard surface with a tough ductile core. Flame hardening provides an ideal method of hardening certain alloy steels not adaptable to case hardening without altering, in any way, the composition of the core material.

The extremely high temperature of the oxy-acetylene flame now makes possible the hardening of thin sections, which must be avoided by other methods because the slow heating rate causes the destruction of desirable physical properties. In many cases of differential hardening surface hardness is sacrificed in order that the core will retain the desired properties. Flame hardening has no such drawback as the heat of input is under specific control, thus the penetration of the surface hardening may be adjusted for the best results. The extreme portability of the flame hardening apparatus makes for high adaptability. In many cases the tool can be brought to the work. Four methods of flame hardening are available. These are, stationary, progressive, spinning and combination.

The stationary method includes the operations wherein the work as well as the blowpipe are held fixed. This method is sometimes referred to as "spot hardening."

The progressive method refers particularly to those operations wherein the blowpipe is directed upon the surface to be hardened in such a manner that it moves in respect to the surface, followed immediately by a stream of water which progressively quenches the heated surface.

Several factors such as the depth of penetration, type of steel, and flame intensity determine the rate of flame travel. On both plane surfaces and circular work the rate of travel varies from 4 to 10 inches per minute. The hardening of a circular path can most satisfactorily be accomplished by spinning the part under the flames of one or more blowpipes, the number depending upon the diameter of the part. The hardening time for this method is determined by variables such as the number of blowpipes, flame intensity, and, of course, the diameter of the piece being treated. Any piece that requires more than 3 minutes should have more blowpipes, or be hardened by the single revolution method.

In those cases where objects of extreme lengths are to be hardened a combination of the progressive and spinning method is used. The rate of flame travel depends upon the previously mentioned variables. Mechanical operations are much more satisfactory and should be used for best results although it is entirely possible to flame harden by hand. Many shops, with a little going over, are readily adaptable to flame hardening due to the extreme simplicity of the machines used. A common lathe, easily fitted with a blowpipe in place of the tool, is readily transformed into a flame hardening machine capable of handling many articles. In most cases the tips are of the interchangeable variety, the size used depending upon the special case under consideration.

Quenching, another important part of flame hardening, presents no involved problems. Most cases require only a small stream of water to cover the path of the flame. If a greater area is to be covered, nozzles are available.

For the progressive of combination methods, the quenching pipe is attached to the blowpipe in such a manner that the exact position necessary for the proper quench is readily obtainable. Independent lines for quenching the hot steel and cooling the blowpipe are preferable. Where spinning operations are used on smaller parts, best results are obtained with a quench covering the entire part instantaneously and flowing slowly in a solid stream until the proper temperature is reached. Flame hardening, with its extreme flexibility and numerous applications, has unlimited possibilities, and at the present time it approaches the ideal as far as the surface hardening of iron and steel is concerned.